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GB 2276098 A US 5998210 A US 5829248 A
US 5396794 A

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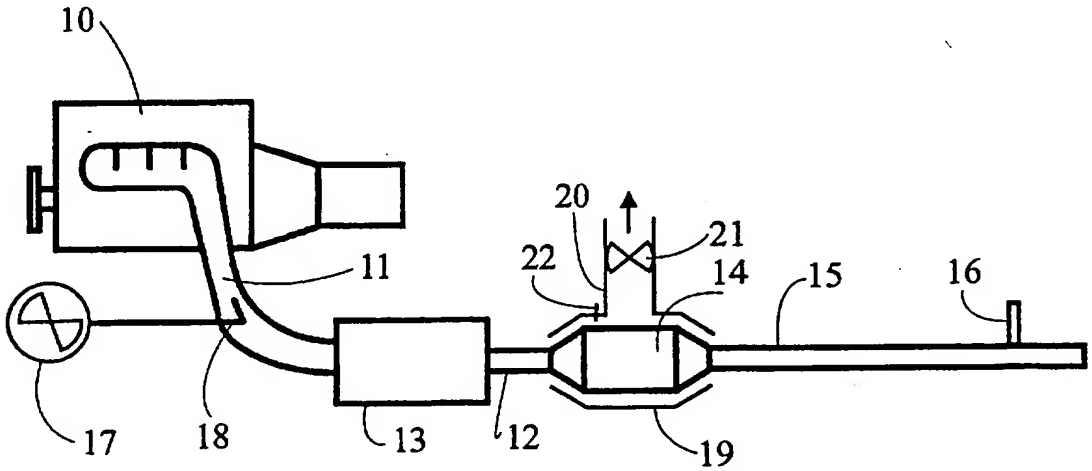
(54) Abstract Title
Method and apparatus for ageing a catalyst

(57) A method of ageing a catalytic converter 14 for use in vehicle development or testing comprises the steps of running an internal combustion engine 10 to provide fuel rich feedgases, injecting secondary air 18 into the feedgases, passing the feedgases through a reaction zone 13 where the feed gases are heated by reaction of the secondary air with excess fuel, controlling the air/fuel ratio of the engine and the volume of feedgases produced by the engine to a level such that the temperature of the feedgases entering the catalyst is in the range 1000°C to 1300°C, and continuing to run the engine for a period sufficient to degrade the emissions performance of the catalytic converter to a desired level. The catalytic converter is subjected to external cooling 20, 21 during the process to avoid damage to its casing.



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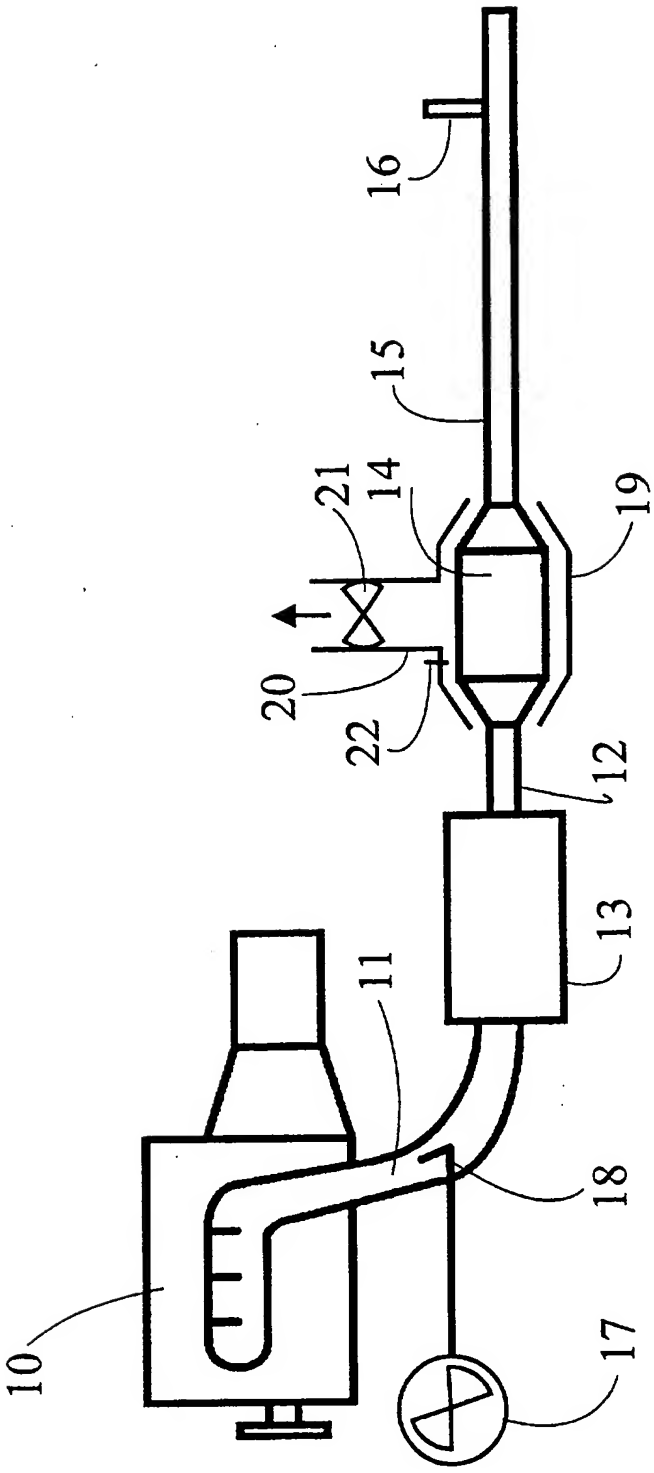
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Process for Ageing a Catalytic Converter

Field of the invention

This is invention relates to a process for ageing a catalytic converter so that it can be used in vehicle development and testing to simulate a converter which has had many thousands of miles of normal use.

Background of the invention

A requirement for sale of vehicles is certification to the appropriate emission standards. Such certification requires demonstration by the manufacturer that emissions can be

controlled to within target levels over, typically, 100,000 miles and that the control system is capable of detecting a malfunction that would cause the emissions to exceed the

100k target level by more than a specified factor.

The diagnostic system is required to diagnose a genuine fault but must not give false indication when no fault is present. Absent on-board measurement of actual emissions, diagnostic systems rely on measurement of an emission related parameter which correlates well with conversion efficiency of the catalyst in a relatively linear manner. For example in the case of hydrocarbon emissions, the oxygen storage of the catalyst, and its effect on transport delays between upstream and downstream sensors, is usually used as a method of inferring catalyst efficiency.

During vehicle development a suitably aged catalyst is required early in the programme to permit diagnostic strategy development and high-mileage emission calibration. The time scales involved in ageing catalysts on vehicles (some 7-8 months to 100k miles and maybe much longer to

catalyst failure) are very significant within program timing and a method of accelerating the ageing process is highly desirable. However, it is essential that any accelerated process accurately maintains the relationship between emissions degradation and the diagnostic parameter such as oxygen storage.

Currently used ageing processes include high-temperature oven ageing and abuse on an engine test rig through misfire or air/fuel ratio perturbation. These processes introduce one, or more, deviations from the characteristics of catalysts which have been subjected to true vehicle ageing and the correlation between diagnostics and emissions using such catalysts aged by such processes is not always as close as desired.

Summary of the invention

According to the invention, we provide a method of ageing a catalytic converter for use in vehicle development or testing comprising the following steps:

a) running an internal combustion engine to provide fuel rich feedgases;

b) injecting secondary air into the feedgases at a flow rate effective to restore the air fuel ratio of the feedgases to ratios which approximate to average in service fuel ratios of the engine for which the aged catalyst is required;

c) passing the feedgases through a reaction zone where the feed gases are heated by reaction of the secondary air with excess fuel;

d) passing the feedgases from the reaction zone through the catalytic converter;

e) controlling the air/fuel ratio of the engine and the volume of feedgases produced by the engine to a level such that the temperature of the feedgases entering the catalyst is in the range 1000°C to 1300°C; and

f) continuing to run the engine to provide such feedgases to the catalytic converter for a period sufficient to degrade the emissions performance of the catalytic converter to a desired level.

The process of the invention ensures that during ageing the feedgas chemical composition and mass flow to the catalyst is closely similar to conditions to which the catalyst would be subjected during normal in vehicle operation but at considerably higher temperatures. Although high temperature feedgases are used and the temperatures within the catalyst are considerably higher that normal, there is a temperature profile within the catalyst that is typical of that prevailing in normal operation. The ageing process of the invention achieves degradation through high temperature alone, keeping the temperature profile within the brick and the chemistry and the mass flow of the feedgases as close as possible to that seen in a vehicle. Thus, for an engine designed to run at stoichiometric air fuel ratios the feedgases are maintained at or near stoichiometric air fuel ratio at a temperature up to 1200 C prior to catalyst entry. A conventional engine, either in a vehicle or on a test-bed, cannot be used to generate such temperatures; engine failure would occur.

Brief description of the drawings

The invention will now be described further, by way of example, with reference to the accompanying drawing, in which the single Figure is a block diagram of apparatus for carrying out the catalyst ageing process of the invention.

Detailed description of the drawings

Referring now to the single figure of the drawings, apparatus for ageing a catalyst converter for use in development and testing of a motor vehicle comprises an

internal combustion gasoline engine 10 mounted in a conventional test cell providing loading of the output, fuel supply and management of the exhaust gases.

An exhaust manifold 11 collects the combustion products from the engine and feeds them to a mixing chamber 13. The catalyst to be aged 14 is assembled in the exhaust 12 downstream of the mixing chamber 13. An extended exhaust pipe 15 leads to oxygen sensor 16. The extended run of pipe allows cooling of the exhaust gases before they reach the sensor.

Secondary air from an air pump 17 driven by the engine 10 enters the exhaust manifold 11 at 18.

Cooling air is pumped through a shroud 19 over the casing of the catalytic converter 14 by fan 21 in a duct 20. A temperature sensor 22 in the duct 19 enables control of the temperature of the outer casing of the catalytic converter during the ageing process by increase or decrease of the speed of the fan 21.

A determination is made of the normal feedgases (including mass flow and air fuel ratio) that the catalytic converter will be subjected to in service in a vehicle. This information can be obtained from measurements on prototype vehicles. As well known, most current motor vehicles use three way catalyst for controlling CO, HC and NOx emissions and normal running is at stoichiometry. A richer mixture is used from high power and the feedgases may be enriched to reflect the proportion of higher power operation expected in service. For vehicles that use other than stoichiometric operation, for example, lean burn operation with occasional rich excursions for NOx trap purge, a determination is also made of the average air fuel ratios to which the catalyst is subjected in service. For lean burn engines the average air fuel ratio would be leaner than stoichiometric.

To age a catalyst for a particular vehicle (usually a vehicle under development prior to production), the catalyst is installed in the apparatus described above and shown in the figure. The engine is started and run up to working temperature. The air/fuel ratio is set rich (usually of the order of XX to 1) and the secondary air is set to restore the air fuel ratio to the mean air fuel ratio that the catalyst would be exposed to in service.

The air fuel ratio at the catalyst is controlled either by an open loop system, using settings determined by experiment, or by a closed loop system using signals from an oxygen sensor 16 downstream of the catalyst and programmed to control the air fuel ratio and mass flow of the engine 10 and also the mass air flow of secondary air.

In the exhaust manifold 11 and in the mixing chamber 13 the hot exhaust gases from the engine combine with the secondary air to create additional heat. The volume and temperature of the feedgases is controlled so that the temperature at the upstream end of the catalyst is between 1000 and 1300°C, preferably between about 1150 and 1200°C. In order to achieve these temperatures it is necessary to use an engine of adequate capacity but this need not be the same as the engine for which the catalyst is being aged. A different engine may be used as long as it is capable of delivering the required mass flow at the required air fuel ratio.

The temperature of the casing is controlled by increasing or decreasing the ventilation of the catalyst casing. Casing temperature is maintained below about 250°C preferably at about 200°C by control of pump 21. Inlet temperature at the catalyst is controlled by increasing or decreasing the proportion of fuel that is burned in the reaction chamber in the presence of secondary air.

The ageing process may be carried out in steady state conditions established as described above. Alternatively, the mass flow and air fuel ratio of the feedgases may be modulated to give a closer simulation of normal running, the average of the running conditions still approximating average conditions in service.

The ageing process is continued until the catalyst displays the desired characteristics in terms of emissions conversion efficiency and oxygen storage capacity. It should be noted that the desired characteristics may not be the same as the characteristics of a catalyst from a vehicle that has done 100k miles in service. Artificially aged catalysts are used for diagnostic strategy development and must replicate the catalyst characteristics that the diagnostic system is required to detect so that the development engineer can determine whether or not his diagnostic system detects such characteristics.

The required duration may be determined by carrying out a pilot process and interrupting it at intervals of about six hours to carrying out emissions testing on the partially aged catalyst and determine the extent of degradation. The pilot process is ended when the required level of degradation is achieved. For subsequent ageing processes on the same kind of catalyst, the procedure is continuous for a duration equal to the sum of the periods of ageing in the pilot process. The period of continuous processing to achieve ageing appropriate for 100,000 miles diagnostics development may be of the order of 35 to 40 hours.

CLAIMS

2. A method of ageing a catalytic converter for use in vehicle development or testing comprising the following steps:

a) running an internal combustion engine to provide fuel rich feedgases;
b) injecting secondary air into the feedgases at a flow rate effective to restore the air fuel ratio of the feedgases to ratios which approximate to average in service fuel ratios of the engine for which the aged catalyst is required;
c) passing the feedgases through a reaction zone where the feed gases are heated by reaction of the secondary air with excess fuel;
d) passing the feedgases from the reaction zone through the catalytic converter;
e) controlling the air/fuel ratio of the engine and the volume of feedgases produced by the engine to a level such that the temperature of the feedgases entering the catalyst is in the range 1000°C to 1300°C; and
f) continuing to run the engine to provide such feedgases to the catalytic converter for a period sufficient to degrade the emissions performance of the catalytic converter to a desired level.

3. A method of ageing a catalytic converter as claimed claim 1 in which the casing of the catalytic converter is subjected to external cooling to maintain structural integrity of the casing.

4. A method of ageing a catalytic converter as claimed claim 2 in which the temperature of the casing of the catalytic converter is maintained below 250°C.

5. A method of ageing a catalytic converter as claimed any one of the preceding claims in which the temperature of the feedgases entering the catalyst is between 1100°C and 1200°C.

6. A method of ageing a catalytic converter as claimed any one of the preceding claims in which the air fuel ratio of the feedgases entering the catalyst is somewhat richer than stoichiometric for ageing a catalyst for an engine for which normal operation is stoichiometric but with richer excursions when full power is required.

7. A method of ageing a catalytic converter as claimed any one of claims 1 to 4 in which the air fuel ratio of the feedgases entering the catalyst is somewhat leaner than stoichiometric for ageing a catalyst for an engine which runs lean at part loads.

8. A method of ageing a catalytic converter as claimed any one of the preceding claims including the step of determining the duration of the ageing process during a test run in which the degradation of the catalyst is periodically checked until the desired degradation is reached and subsequently running the ageing process continuously for the total time taken to achieve the desired degradation.

9. A method of ageing a catalytic converter substantially as hereinbefore described with reference to and as shown in the accompanying drawing.

10. Apparatus for ageing a catalytic converter comprising:
a) an internal combustion engine arranged to provide fuel rich feedgases;
b) a secondary air pump for injecting secondary air into the feedgases at a flow rate effective to restore the air fuel ratio of the feedgases to ratios which approximate to average in service fuel ratios of the engine for which the aged catalyst is required;

c) a reaction zone in which the feed gases are heated by reaction of the secondary air with excess fuel;

d) means for passing the feedgases from the reaction zone through the catalytic converter;

e) process control means for controlling the air/fuel ratio of the engine and the volume of feedgases produced by the engine to a level such that the temperature of the feedgases entering the catalyst is in the range 1000°C to 1300°C; and

f) said process control means being arranged to continue to run the engine to provide such feedgases to the catalytic converter for a period sufficient to degrade the emissions performance of the catalytic converter to a desired level.

11. Apparatus for ageing a catalytic converter as claimed in claim 9 including cooling means arranged to cool the casing of the catalytic converter.

12. Apparatus for ageing a catalytic converter substantially as hereinbefore described with reference to and as shown in the accompanying drawing.

INVESTOR IN PEOPLE

Application No: GB 9928294.9 **Examiner:** Jason Scott
Claims searched: All **Date of search:** 19 July 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): B1W (WG)

Int Cl (Ed.7): B01D (53/94); F01N

Other: ONLINE: WPI, JAPIO, EPODOC

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB 2276098 A	PIERBURG See whole document	
A	US 5998210	FORD See whole document	
A	US 5829248	ENVIRONMENTAL ENGINEERING See whole document	
X	US 5396794	APPLIED COMPUTING See whole document and in particular column 5, line 60 to column 6, line 37	2 & 10

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.